A NEW VIEW OF THE BLUE PLANET
The TOPEX/POSEIDON Project --

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INTRODUCTION

TOPEX/POSEIDON, a joint project between the United States and France, is the first space mission specifically designed to study circulation of the world's oceans and is providing oceanographers with the first truly global observing system. Remote sensing of the oceans by satellite provides data that is dense, timely, and very precise. This collaborative effort of the National Aeronautics and Space Administration (NASA) and the Centre National d' Etudes Spatiales (CNES) has resulted in revolutionary sea level measurements that are accurate to within a few centimeters over thousands of kilometers of open ocean. The large-scale pattern of global circulation is being mapped on a routine basis for the first time, allowing precise determination of the seasonal changes of the oceans, as well as tracking the development of the El Niño condition that affects weather worldwide. TOPEX/POSEIDON is managed by the Jet. Propulsion Laboratory for NASA.

CLIMATE AND THE OCEANS

More than two-thirds of Earth, the blue planet, is covered by water. The movement of water over ocean basins has a direct effect on the Earth's climate. Oceans are the major reservoir of heat on our planet and ocean circulation is the primary means of redistributing that heat around the globe. More than one-half of the heat transported between the equate]- and the poles is carried by the oceans, the remainder is carried by the atmosphere. Because water is 900 times more dense than air, oceans are the thermal memory of the climate system. The enormous heat, capacity of the oceans and the. transport_. of this heat around the world greatly reduces the large temperatures differences that would otherwise occur throughout the world. To help understand how the oceans regulate our climate, we must understand global ocean circulation. The extent to which the oceans moderate our climate is determined primarily by the heat that is carried around the world by ocean currents.

THE TOPEX/POSEIDON MISSION

Until recently very little was known about global ocean circulation. in the past, buoys and ships were the source of most ocean current data and these data were sparse in time and

space . Ship data came mostly from vessel s travel ing t-he commerci al shi ppi ng l ants and buoy data from along the coastlines. This information was insufficient to allow an adequate understanding of global ocean circulation. Remote sensing of the oceans from space was the answer to providing meaningful , robust- data. Measuring the topography of the sea surface is the key to understanding ocean circulation. The dynamic topography of the oceans is directly related to the speed and direction of the currents. With a measurement of sea-level being taken every second of the mission, more information regarding global. circulation is being acquired every 10 days than has been during the previous 100 years.

The TOPEX/POSEIDON satellite was launched August 10, 1.992 by an Ariane 4 rocket from the European Space Agency's Guiana Space Center in French Guiana, South America. Almost three years of data has been collected. TOPEX/POSEIDON has been very successful in meeting its objective of gathering data to help determine how ocean circulation affects the Earth's climate.

The satellite is in a circular orbit around the Earth at an altitude of 1336 km with an inclination of 66 degrees to the equator and orbits the Earth once every 112 minutes. It. maps 95% of the ice-free oceans every 10 days, at which time it returns to within one kilometer of the same location on Earth and begins another 10 day cycle. A measurement of the absolute sea level relative to the center-of-mass of the Earth is obtained once every second with an accuracy of about 4 centimeters. TOPEX/POSEIDON provides the best available snapshot of global ocean topography.

The satellite, weighing nearly 2500Kg, is 5.5 meters long and 2.8 meters wide. An 8.9 meter by 3.3 meter solar panel supplies the almost 1000 watts required to power the satellite. The satellite bus and four of the six instruments were provided by NASA. CNES supplied the other two instruments and the Ariane launch. Two of the instruments are radar altimeters which measure the distance between the satellite and the ocean surface, a NASA two-frequency altimeter and a CNES single frequency altimeter. The C-band frequency on the NASA altimeter measures the ionosphere to correct for its delaying effect. upon the roundtrip-light-time of the primary Ku-band frequency. The CNES altimeter also operates at Ku-band and data from the CNES doppler tracking receiver is used to correct for the effect-s of the ionosphere. A microwave radiometer measures the atmospheric water vapor to correct for its effect on the path delay of the altimeter measurements. The remaining three instruments provide data to determine the position of the satellite in relationship to the center of the Earth. These are a NASA Global. Positioning System receiver, NASA laser beam reflectors, and a CNES doppler tracking receiver. The radars measure the distance between the satellite and the ocean surface. The satellite's orbit and precise position from the Earth's center is also determined. The difference of these

two measurements is the sea level as measured from the center of the Earth.

SCIENCE FROM TOPEX/POSEIDON

The exceptional quality of the TOPEX/POSEIDON data has provided oceanographers the basis for a significant advance in ocean circulation knowledge and its effects on climate variability and seasonal forecasting. More than 1.00 scientists from 9 countries use the TOPEX/POSEIDON data to produce global maps showing seasonal variations in sea level, the direction and speed of currents, and the location of swirls of water currents that are called ocean eddies. A whirlpool. is one type of eddy. The average seasonal sea level change in the Northern Hemisphere is about twice as large as in the Southern Hemisphere. This is partly due to the larger oceanic areas in the Southern Hemisphere, which moderate the seasonal changes.

A three millimeter per year increase in the average global sea level has been measured by TOPEX/POSEIDON and may provide corroborating evidence of global warming. This increase is in general agreement with tide gauge data obtained over the last century and is roughly equivalent to the rate expected from global warming. These results are preliminary and could reflect a short-term variation rather than the long-term increase expected from global warming.

TOPEX/POSEIDON detected an increase in sea level in the Pacific which allowed oceanographers to follow the 1992-93 El Nino event.. E] Nino begins when warm water builds up in the equatorial Pacific and moves eastward toward the coast of the Americas. It can bring devastating weather to several global regions, including heavy rains and flooding to California, colder than normal winters across the United Stat-es, and severe droughts and dust storms to Australia. Although oceanographers can not predict when an El Nino will occur, the TOPEX/POSEIDON data can give several months warning before the actual onset of a new cycle.

In the Gulf of Mexico, TOPEX/POSEIDON is helping scientists and oil companies study potentially dangerous ocean phenomena that can disrupt off-shore oil drilling. Oil drilling operations in deep water can be adversely affected by high ocean currents. Eddies in the gulf have caused serious operational problems, including delays of several weeks, lost and damaged equipment, and millions of dollars in unproductive expense. The Gulf of Mexico has some of the largest eddies in the world, ranging up to 400 kilometers in diameter. TOPEX/POSEIDON data is being used to identify these eddies and track their movement.

THE FUTURE

Scientist-s have determined that 20 years of sea level data is required to identify and understand the long-term signals in the

oceans . 'I'he TOPEX/POSEIDON mission is planned to continue for 3 more years. In order to provide these data to the science community after TOPEX/POSEIDON, NASA and CNES are planning a follow--on to this mission. The follow-on will. ensure continuation of these unprecedented measurement s well into the next. century.